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Report to Congressional Committees

August 1997

B-2 Bomber

Cost and Operational Issues

GAO/NSIAD-97-181

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United States
General Accounting Office
Washington, D.C. 20548

National Security and
International Affairs Division

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August 14, 1997

Congressional Committees

The conference report on the National Defense Authorization Act for Fiscal Year 1994 requires us to report to the congressional defense committees at regular intervals on the total acquisition costs of the B-2 bomber through the completion of the production program. The Air Force is currently testing the B-2 and plans to complete the production program, including planned block 30 modifications, by July 2000. This, our fourth report,[1] provides the current status of cost and operational issues.

Background

B-2 operational requirements specify that the weapon system have "low-observable" (stealth) characteristics and sufficient range and payload capability to deliver precision-guided conventional or nuclear weapons anywhere in the world with enhanced survivability. The B-2 combines conventional and state-of-the-art technology, such as special shaping and radar-absorbing materials, to achieve low-observability characteristics, high aerodynamic efficiency, and a large payload capacity. The blending of these technologies makes the aircraft complex and costly to develop, produce, and in some respects maintain.

In the early 1990s, the number of B-2s to be acquired was reduced from 132 to 20 operational aircraft. The 20 aircraft include 15 production aircraft and 5 of 6 test aircraft that are to be modified to a fully capable operational configuration. In March 1996, the President directed that the one remaining test aircraft be upgraded to a fully capable operational configuration, bringing the total operational B-2s to be acquired to 21.

B-2 development started in 1981. Production of long lead-time aircraft components began in 1986 and flight testing was initiated in 1989. The lengthy development and test program, which has been implemented concurrently with the production program for about 11 years, required the Air Force to devise a mechanism for initially accepting partially capable aircraft until their full capability could be demonstrated in the test program. Therefore, the Air Force agreed to accept the 15 production aircraft in 3 configurations—10 in a training configuration, 3 in an interim configuration, and 2 in the fully capable configuration known as block 30. The block 30 configuration is planned to be the first fully capable

[1]The three prior reports are listed at the end of this report.

configuration that would meet all the essential employment capabilities[2] defined by the Air Force.

All aircraft not delivered in the block 30 configuration, including test aircraft, have to be modified extensively to make them fully capable. Some of the aircraft in a training configuration have been modified to an interim configuration. The modification efforts began in 1995 and are scheduled to be complete in July 2000. The total production period for the 21 aircraft, including modifications to bring all B-2s into the fully capable configuration, is expected to be about 14 years. Flight testing was planned to take 4 years but has taken about 8 years and is not yet completed. The Air Force extended the estimated completion of flight testing from July 1997 to March 1998.

Results in Brief

The total cost of the B-2 appears to have stabilized. The Air Force has reported that the total estimated B-2 acquisition costs (development, procurement, and military construction) decreased from $44,946 million in early 1995 to $44,754 million in early 1997. The estimated cost declined even though Congress added new requirements to the B-2 program and provided additional funds of $734 million in fiscal years 1995, 1996, and 1997. Air Force officials advised us that the $44,754 million in cost reported to Congress was understated by $89 million. They said that the impact of the understatement would be that two of the test aircraft would not be fully upgraded to block 30 (making them less than fully capable). Through fiscal year 1997, Congress appropriated funds for about 96 percent of the estimated total cost of $44,754 million.

Although the cost estimate has not changed substantially since 1995, costs could increase if (1) the flight test program is extended beyond March 1998, (2) more performance deficiencies than predicted are identified during the remaining portions of the acquisition program, and (3) unplanned development and procurement activities become necessary to better maintain the low-observable features of the B-2s.

The Air Force declared on April 1, 1997, that the B-2s in an interim configuration had achieved initial operational capability. However, the Air Force decided it was unrealistic to plan on deploying the interim aircraft to forward operating locations because of difficulties being experienced in maintaining low-observable characteristics at the B-2's main operating

[2]Essential employment capabilities are the characteristics and capabilities required by the Air Force to satisfy the full operational spectrum of the B-2.

base. The Air Force is reviewing specific B-2 deployment requirements and working to resolve deployment-related problems by the time the B-2s are scheduled to be fully capable in 1999.

Total Cost of the B-2 Appears to Have Stabilized

The Air Force's estimate of the total program cost for the B-2 program has changed less than 1 percent since 1994; however, the estimate has been affected by changes made by both Congress and the Air Force. Table 1.1 shows the Air Force's 1994-96 cost estimates for the development, procurement, and military construction of the B-2 as reported in annual selected acquisition reports. Through fiscal year 1997, the Air Force was appropriated $43,178 million, or 96 percent, of the $44,754 million total program estimate. This leaves $1,576 million to be appropriated for fiscal years 1998-2004.

Table 1.1: Estimated B-2 Acquisition Costs

Then-year dollars in millions

Selected acquisition report	Operational aircraft quantity	Development and procurement estimate	Military construction estimate	Total acquisition program estimate	Total program unit acquisition cost
Dec. 1994	20	$44,390	$556	$44,946	$2,247
Dec. 1995	20	$44,760	$550	$45,310	$2,265
Dec. 1996	21	$44,200	$554	$44,754	$2,131

Note: Details of the fiscal year 1998 President's budget for the B-2 are included in appendix 1.

Source: B-2 Selected Acquisition Reports.

The December 1996 estimate included costs to complete the program for 20 operational B-2s and other changes in the program. In the last 3 fiscal years, Congress added $734 million to the B-2 program—$125 million to preserve the B-2 industrial base, $493 million to upgrade the first test aircraft to operational status, and $116 million to enhance the block 30 capabilities. Enhanced capabilities include making the B-2 capable of launching the Joint Stand Off Weapon and a near-precision conventional penetrating bomb.

The Air Force changes decreased various elements of the estimated development and procurement costs. Those decreases exceeded congressional additions, resulting in the overall net reduction in the total B-2 cost estimate. For example, between fiscal year 1997 and 1998,

estimates for B-2 spares, support, and nonrecurring air vehicle cost decreased over $900 million. Spare parts estimates were reduced by $358 million because the Air Force now plans to fly fewer and shorter aircraft sorties and because the methodology for computing spare parts requirements changed. Interim contractor support estimates were also reduced by $142 million because parts reliability, according to the Air Force, has been better than anticipated. Other support decreases totaling $170 million covered peculiar support equipment, data, and training items. In addition to changes in the B-2 support estimate, the Air Force decreased its estimate for nonrecurring air vehicle cost by $237 million.

According to the Air Force, the estimate of development cost reported in the December 1996 B-2 Selected Acquisition Report (included in table 1.1) and the fiscal year 1998 President's budget (app. I) is understated by $89 million. Air Force officials said that without these funds, two of the test aircraft would not be upgraded to fully capable aircraft, leaving only 19 fully capable B-2s.

B-2 Cost Increases Are Possible

B-2 estimated costs could increase if (1) the flight test program is extended beyond March 1998, (2) more B-2 performance deficiencies are identified during the time remaining in the acquisition program, and (3) additional development and procurement activities are initiated to better maintain the low-observable features of the B-2s.

Extending the Flight Test Program

The flight test program was not fully completed as scheduled on July 1, 1997, and the Air Force plans to extend flight testing with one test aircraft through March 1998. The Air Force is currently defining detailed testing that will be required and has included $28 million in the fiscal year 1998 budget to cover the extended flight test program. Any additional extension of testing, however, could increase the estimated B-2 cost. Some of the areas to be further tested are

- terrain-following/terrain-avoidance radar performance in the rain,
- mission effectiveness tests of the low-observable features,
- ground and flight tests of the environmental control system and auxiliary power units, and
- certain tests of the defensive management system.

We plan to report on the results of B-2 testing after the Air Force issues reports scheduled for late 1997 and early 1998.

Other Deficiencies

Working on flight tests, aircraft production, and modifications concurrently has created the need for further corrections of deficiencies after fully capable aircraft are delivered and could cause development costs to increase. As of May 1997, the Air Force officials had identified 13 corrections that cannot be incorporated into up to nine aircraft during production or during the modification process. They estimate another 60 deficiencies could be identified that could impact the B-2s. These officials added that new corrections that cannot be incorporated during the modification process would be incorporated by retrofitting the aircraft at some future time. The cost estimate for production includes over $500 million in reserves (fiscal year 1993 and prior year funds) that are available for cost overruns and other anticipated costs. However, the development estimate includes only $12 million in reserves to correct deficiencies in the test aircraft. Air Force officials said that if significantly more or costly deficiencies are identified, development costs could increase.

Deployment and Low-Observable Maintenance

The Air Force has concluded it could not effectively deploy B-2s to forward operating locations without sheltering the aircraft to preserve and maintain its low-observable features. Accordingly, if permanent or temporary shelters must be developed and built at selected forward operation locations or additional support equipment must be acquired to meet deployment and maintenance requirements, additional costs will be incurred.

Initial Operating Capability Achieved, but B-2 Cannot Be Deployed as Planned

According to the Air Force, the B-2 achieved initial operational capability on April 1, 1997, with interim aircraft capable of flying nuclear and limited conventional missions. The interim B-2 is supposed to be capable of participating in nuclear or conventional warfare either from its main operating base at Whiteman Air Force Base, Missouri, or from a forward operating location outside the continental United States. While the B-2's performance met requirements for initial operations, the aircraft are unable to meet intended deployment requirements because some low-observable features require substantial maintenance and the aircraft are more sensitive to climate and moisture than expected. As a result, the Air Force has eliminated the deployment requirement for interim aircraft and is evaluating potential actions to allow deployment when fully capable aircraft are delivered. Full operational capability of the B-2 is planned to be achieved in 1999.

Initial Operational Capabilities Demonstrated

The Air Force demonstrated that interim B-2 aircraft can carry and deliver unguided Mk 84 bombs or the precision-guided Global Positioning System (GPS) aided munition (GAM) in the conventional role or B-83/B-61 nuclear weapons in the nuclear role. Reports of flight tests and demonstrations indicated the GAM to be an effective all-weather weapon in attacking fixed targets with near-precision accuracy. In one demonstration, 3 B-2s destroyed 16 targets using 16 GAMs dropped from over 40,000 feet. In addition, the interim aircraft have automatic terrain-following capability as low as 600 feet and some of the capabilities of the planned defensive management system. According to Air Force officials, the demonstrated capabilities are more than adequate to perform the mission defined for the interim configuration when operating from Whiteman Air Force Base, the B-2's main operating base.

B-2s Cannot Be Deployed as Planned

The Air Force decided it was unrealistic to deploy the B-2 without shelters, as planned, because some low-observable materials are not as durable as expected and require lengthy maintenance, some in an environmentally controlled shelter after each flight. In addition, B-2s must be kept in shelters because of their sensitivity to moisture, water, and other severe climatic conditions. Air Force operational requirements for the B-2 intended for both the interim and fully capable B-2s to be capable of deploying to forward operating locations, without shelters, in all types of weather and climates. The Air Force is reviewing specific B-2 deployment requirements and working to resolve deployment-related problems by the time the B-2s are scheduled to be fully capable in 1999.

The operational test report for the interim aircraft stated the aircraft need frequent and lengthy maintenance and are sensitive to extreme climates and moisture. Tests showed that some low-observable materials on the aircraft were damaged each time the aircraft flew and that repair of those materials accounted for 39 percent of the 80 maintenance man-hours per flight hour experienced by the B-2 during flight testing. This is about three times greater than the next largest contributor to maintenance man-hours, which was aircraft structures. The current goal for total maintenance man-hours per flying hour is 60 hours, and the ultimate goal is 50 hours. The actual B-2 maintenance man-hours per flying hour at Whiteman Air Force Base averaged 124 hours over 12 months ending in March 1997. A major factor in maintenance of low-observable materials is the long time required to repair the damaged materials and aircraft surfaces. During operational testing of the interim configuration, low-observable materials took from 30 to 80 hours to repair and cure, and the processes require a

shelter with a temperature and humidity controlled environment for proper curing.

Problems with low-observable materials have also affected the percentage of time the B-2 was partially or fully capable of completing a mission, which was significantly less when low observability was considered. When low observability was not considered, the mission-capable rate was 66 percent for a 12-month period ending March 1997. However, when low-observability problems were considered for the same period of time, the rate dropped significantly to 26 percent.

Testing indicated that B-2s are also sensitive to extreme climates, water, and humidity—exposure to water or moisture can damage some of the low-observable enhancing surfaces on the aircraft. Further, exposure to water or moisture that causes water to accumulate in aircraft compartments, ducts, and valves can cause systems to malfunction. If accumulated water freezes, it can take up to 24 hours to thaw and drain. Air Force officials said it is unlikely that the aircraft's sensitivity to moisture and climates or the need for controlled environments to fix low-observability problems will ever be fully resolved, even with improved materials and repair processes. Therefore, if B-2s are to be deployed, some form of aircraft sheltering at a forward operating location will likely become a requirement in the future.

Air Force test officials stated that maintenance of low-observable features is an issue that requires significant further study and that the percentage of maintenance hours required to repair low-observable materials would increase even more before there are reductions. They said technological improvements in materials and repair processes will be required. Air Combat Command considers low-observable maintainability to be its number one supportability issue, and the Air Force has efforts underway to develop new materials, procedures, and support equipment. It is currently changing some of the materials on the aircraft to improve durability and reduce repair times. It has also established procedures to monitor conditions of low-observable materials on the operational aircraft and developed a model that characterizes the operational impacts of material degradations so that repairs can be prioritized relative to the operational requirements of the B-2s.

Agency Comments

In commenting on a draft of this report, the Department of Defense generally agreed with the report. The Department's comments are

presented in their entirety in appendix II, along with our evaluation of them.

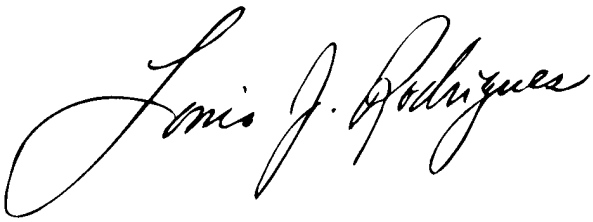
Scope and Methodology

To identify cost issues, we reviewed annual cost and budgetary estimates, financial and management reports, contract cost reports, program schedules and plans, and other documents. We compared annual estimates from 1995 to 1997, identifying increases and decreases and the basis for the changes. We interviewed Air Force, Defense Contract Management Command, and contractor financial and technical mangers to obtain explanations and information on cost issues and risks remaining in the B-2 program that were not included in the official reports and documents reviewed. To identify operational issues, we reviewed Air Force B-2 contract and operational requirements documents and operational test reports. We discussed deficiencies and planned development and corrective actions with Air Force B-2 Program, Test, and Operational Command officials to determine the nature and extent of problems, the impact of problems on operations, and schedules for achieving full capability.

We performed our review from November 1996 through July 1997 in accordance with generally accepted government auditing standards.

We are sending copies of this report to the Secretaries of Defense and the Air Force, the Director of the Office of Management and Budget, and other interested parties. We will make copies available to others upon request.

Please contract me on (202) 512-4841 if you or your staff have any questions concerning this report. Major contributors to this report are listed in appendix III.



Louis J. Rodrigues
Director, Defense Acquisitions Issues

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The Honorable John P. Murtha
Ranking Minority Member
Subcommittee on National Security
Committee on Appropriations
House of Representatives

Contents

Abbreviations

DOD	Department of Defense
GAM	GPS aided munition
GPS	Global Positioning System

B-2 Program Fiscal Year 1998 President's Budget

Then-year dollars in millions

	Fiscal year						
	1996/prior	**1997**	**1998**	**1999**	**2000**	**2001/04**	**Total**
Development program							
Northrop	$20,268.9	$489.1	$286.5	$15.8	$183.4	$51.8	**$21,295.6**
GE Engines	564.0	4.9	0	0	0	0	**568.9**
Armament	121.2	3.6	0	0	0	0	**124.7**
Aircrew training	561.2	0.2	0	0	0	0	**561.4**
Mission planning	252.6	21.6	18.8	8.2	0	0	**301.2**
Government test	732.7	36.8	28.1	12.2	13.0	40.4	**863.0**
Other government tests	573.7	2.3	1.4	0.5	0.5	0.1	**579.5**
Engineering changes	0	9.8	14.9	2.4	5.0	2.2	**34.3**
Direct release	316.1	27.2	5.9	6.1	7.6	4.9	**367.7**
Development total	**$23,391.4**	**$595.5**	**$355.8**	**$44.9**	**$209.5**	**$99.3**	**$24,696.3**
Procurement program							
Air vehicle	$15,276.8	$38.8	$33.3	$24.3	$49.0	$54.1	**$15,476.3**
Equipment/data/training	1,418.3	24.7	26.0	9.9	2.1	1.9	**1,482.9**
Interim contractor support	154.6	4.5	44.0	45.6	47.6	10.0	**306.3**
Spares	961.4	35.0	67.9	27.5	26.0	12.7	**1,130.5**
Retrofit	105.5	6.1	13.8	16.3	22.2	44.1	**208.0**
Other government costs	90.4	7.1	17.2	17.1	15.4	0.6	**147.8**
Software support	400.2	1.1	42.4	127.4	0	0	**570.9**
Mission support	12.3	15.1	11.5	11.2	9.4	9.4	**68.9**
Facilities	108.9	3.6	0	0	0	0	**112.5**
Procurement total	**$18,528.4**	**$136.0**	**$255.9**	**$279.3**	**$171.7**	**$132.8**	**$19,504.1**
Military construction total	**$526.5**	**0**	**$27.1**	**0**	**0**	**0**	**$553.6**
B-2 program total	**$42,446.3**	**$731.5**	**$638.8**	**$324.2**	**$381.2**	**$232.1**	**$44,754.0**

Source: Air Force B-2 Program Office.

Comments From the Department of Defense

Note: GAO comments supplementing those in the report text appear at the end of this appendix.

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July 14, 1997

Mr. Louis J. Rodrigues
Director, Defense Acquisitions Issues
National Security and International
Affairs Division
U.S. General Accounting Office
Washington D.C. 20548

Dear Mr. Rodrigues:

This is the Department of Defense (DoD) response to the General Accounting Office (GAO) draft report, "B-2 Bomber: Cost and Operational Issues," dated June 13, 1997 (GAO Code 707202), OSD Case 1385. The Department has reviewed and generally concurs with the report.

Detailed comments are enclosed. Needed technical corrections have been provided separately.

The Department appreciates the opportunity to comment on the draft report.

Sincerely,

George R. Schneiter
Director
Strategic and Tactical Systems

Enclosure

GAO DRAFT REPORT - DATED JUNE 13, 1997
(GAO CODE 707202) OSD CASE 1385

"B-2 BOMBER: COST AND OPERATIONAL ISSUES"

DEPARTMENT OF DEFENSE COMMENTS
*****

Now on p. 4.

See comment 1.

Total Cost of the B-2 Has Stabilized: The GAO cited the December 1996 B-2 Selected Acquisition Report and the fiscal year 1998 President's budget as reporting the estimate of development cost was understated by $89 million. Further, the GAO reported that Air Force officials stated that without these funds, two of the test aircraft would not be upgraded to fully capable aircraft, leaving only 19 fully capable B-2s. (p. 6/GAO Draft Report)

DoD Response: The Department has addressed the shortfall and plans that all 21 B-2 aircraft will be upgraded to the mature Block 30 configuration.

Now on p. 4.

See comment 2.

Extending the Flight Test Program: The GAO observed that one factor that could increase B-2 costs is extending the flight test program. The GAO reported that the flight test program was scheduled to be completed July 1, 1997, but that the Air Force was assessing whether it needed to extend flight testing to complete unfinished development or operational testing as well as testing for planned upgrades. (pp.6-7/GAO Draft Report)

DoD Response: Some developmental testing remains that will involve the use of a test aircraft, AV-3, after July 1, 1997. The primary focus of the effort will be the defensive management and terrain following/terrain avoidance systems. This work is planned to be funded from within program resources and be completed by March 1998. After March 1998, AV-3 will enter the modification line for retrofit/upgrade from a test asset to a fully operational Block 30 aircraft.

Now on p. 5.

See comment 3.

Other Deficiencies: The GAO also observed that B-2 costs could increase if more performance deficiencies are identified than anticipated. The GAO report states that as of March 1997, Air Force officials had identified 13 corrections that cannot be incorporated into at least five aircraft during the production or modification processes. They further observed that the Air Force officials report the necessary corrections would be incorporated at some future time. (pp.7-8/GAO Draft Report)

DoD Response: The 13 deficiencies cited were identified under the basic contract and will not require additional funds to correct. They will most likely be incorporated into the applicable aircraft as time-change technical orders.

Now on p. 6.

B-2s Cannot Be Deployed: The GAO observed that the Air Force cannot deploy the B-2 because some low-observable materials are not as durable as expected and require lengthy maintenance in an environmentally controlled shelter after each flight. In addition, B-2s must be kept in shelters because of their sensitivity to moisture, water, and other severe climatic conditions. (p.9/GAO Draft Report)

See comment 4.

DoD Response: The B-2 can be deployed, but at the present time it would be difficult to operate the B-2 from a deployed location. The deployment requirement remains for the fully capable Block 30 B-2 fleet, and the appropriate equipment, spare parts, and procedures are being developed. Some, but not all, low-observable materials require an environmentally (heat and humidity) controlled facility for maintenance. B-2 aircraft do not have to be kept in hangars at all times, but sheltering facilitates maintenance, is warranted during adverse weather conditions, and protects low-observable surfaces from damage.

The following are GAO's comments on the Department of Defense's (DOD) letter, dated July 14, 1997.

GAO Comments

1. DOD officials told us they plan to address the funding shortfall during the fiscal year 1999 DOD planning and budgeting process, which is incomplete at this time.

2. Cost growth risks will continue until the extent of changes needed as a result of the remaining test effort has been defined by the Air Force and it has some assurance that needed changes can be completed with existing program resources.

3. DOD's comments addressed 13 deficiencies already identified but did not address the potential impact of an additional 60 deficiencies that DOD suggested could occur. Although the cost estimate for development and production includes some provisions for correcting deficiencies that have not yet been defined, the amounts included are intended to accommodate corrections of deficiencies that are relatively minor. If the Air Force identifies any deficiencies that involve significant costs to correct, cost estimates could increase.

4. Design requirements for the B-2 include provisions for the B-2 aircraft to be deployed, without shelters, in all types of temperatures and climates. The operational test report for the interim B-2 concluded the B-2 must be sheltered or exposed only to the most benign environments (low humidity, no precipitation, moderate temperatures). According to B-2 Combined Test Force officials, permanent shelters at deployed locations are required. Therefore, while DOD commented that it is possible to deploy the B-2, it appears that effective operations from a forward operation location will require additional facilities and equipment not included in the original plan. The Air Force is still working to identify these additional requirements.

Major Contributors to This Report

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Related GAO Products

B-2 Bomber: Status of Efforts to Acquire 21 Operational Aircraft (GAO/NSIAD-97-11, Oct. 2, 1996).

B-2 Bomber: Status of Cost, Development, and Production (GAO/NSIAD-95-164, Aug. 4, 1995).

B-2 Bomber: Cost to Complete 20 Aircraft Is Uncertain (GAO/NSIAD-94-217, Sept. 8, 1994).

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